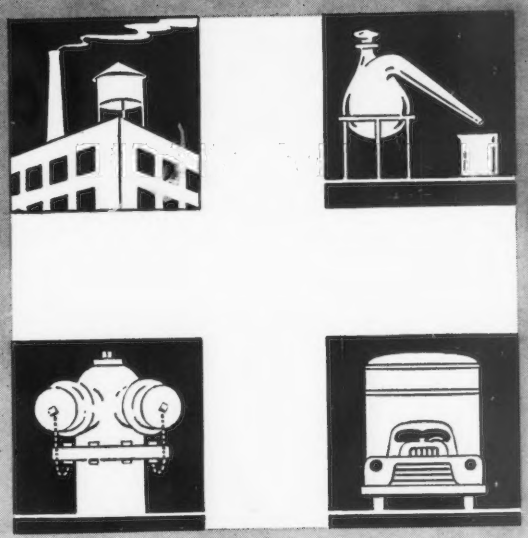
The Journal

OF THE AMERICAN SOCIETY OF SAFETY ENGINEERS



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AMERICAN SOCIETY OF SAFETY ENGINEERS

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425 North Michigan Avenue, Chicago 11, Ill.

managing director, J. B. JOHNSON

editor, ROBERT E. BEIGHLEY

associate editor, CHARLES S. WOLFF

art direction, THAD HACKETT

OFFICERS. 1956-57

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ON PAGE 34 of this issue the Journal is presenting a panel discussion on the controversial subject, "Registration of Safety Engineers." Panel participants, who originally presented their arguments at a meeting of the Society's San Francisco Chapter, are all members of the chapter. They include WILLIAM S. TICKLE, safety consultant, Business and Industrial Staff Services, Oakland, California. Mr. Tickle is consultant to the City of Oakland and holds the copyright on the speed-time-distance slide rule which he designed. A graduate of the University of California, he formerly was accident analyst with the Capital Transit Company, Washington, D.C. He joined the Society in 1948 . . . THOMAS SOULE, chief safety engineer, Industrial Indemnity Company of California. Mr. Soule, who has held this position for 21 years, has been a member of the Society since 1935. Graduated from Adrian College, for 17 years he worked as a mining engineer. He is safety consultant for the California Apprenticeship Council and author of several books, including the well known reference, "Safety Engineering Standards" . . . EDGAR N. GOLDSTINE, accident prevention consultant, San Francisco. A consultant with construction and industrial organizations for the last 22 years, Mr. Goldstine holds a B.S. in civil engineering from Rose Polytechnic Institute. He joined the Society in 1934, served as San Francisco Chapter newsletter editor for 10 years and as editor of the NSC Construction Section newsletter for 17 years. He is a past general chairman of the Construction Section . . . A. CHURCHILL BLACKMAN, chief, Division of Industrial Safety, California Department of Industrial Relations. A graduate of Cornell University (mechanical engineering), Mr. Blackman has worked as an insurance company engineer and as an industrial hygienist. He has been a member of the Society since 1944.

Our President Speaks on SAFETY

DURING the last five months I have had the privilege of visiting with some 33 chapters of the American Society of Safety Engineers. Only by visiting these chapters and seeing them at work do you get the true feeling that we are going places and doing big things for the conservation of life and property. From Montreal, Canada, to Houston, Texas... from Boston, Massachusetts, to Seattle, Washington, or Los Angeles, California ... the spirit is the same. There is a desire by the chapters to improve their standing professionally and to help their communities gain a better understanding of accident prevention — a desire that transcends the safety engineer's job requirements and embraces the home, the highway and all public places.

I met with a small group of safety engineers in the middle of Idaho. The group has been meeting once every three months to discuss common problems. These men travel 50 to 100 miles to attend meetings. They wanted to know what they had to do to form a chapter of this Society. At a recent meeting in the heart of Tennessee I met with a delegation from Chattanooga, a group which apparently has met all the requirements for chapter status. The one desire of these men was to get their charter by September so that they could get going in the fall. Other groups in other states are equally desirous of qualifying for chapter status. It is most heart warming and encouraging to witness this trend. It is a healthy indication of the future growth of the Society.

In sharp contrast with this enthusiasm has been the several letters that have come to my desk since the announcement of the proposed increase in Society membership dues. In general the question was, "What do I get for my membership dollar?"

Some of the letters reflect a sincere inquiry into the use that is made of that part of the dues that goes to the national Society. Others indicate a resistance to an increase in dues irrespective of the need. While the number of such cases has been very small in relation to the 7,000 plus members of the Society, the inquiries indicate that some members have not kept themselves fully informed of the services they receive as Society members.

Space does not permit a complete review, nor am I inclined to go on the defensive to uphold the past and present work of the Society since its inception in 1915 and particularly since our return to independent status in 1947. I do believe, however, that the following illustrations of action taken over the past few months will give a small sampling of what the Society is doing on a national level to improve the standing of safety engineers.

Recently the Washington Chapter brought to our attention legislation which apparently was discriminating against qualified safety engineers. The bill was up for hearing before a Senate committee and quick action was needed to give our profession representation before the committee. The Society headquarters staff went to work and, after contacting our Committee on Laws and Regulations, secured the services of an attorney and followed through to a point where the bill is now held in committee. If the bill is brought forward next year, we are assured that full consideration will be given to our plea.

The Eighth National Conference on Standards in San Francisco this fall will include a half day session on accident prevention sponsored by your Society through the active work of the San Francisco Chapter.

In December the annual meeting of the American Association for the Advancement of Science will include a half day session sponsored by the Society.

Of direct benefit to individual members is a survey, to be made of all Society members by the Committee on Improved Membership Services, to determine the present status of safety engineers. The survey will include their business, industry or government affiliation; position in their organization; educational background; experience and professional status; annual salary range. This information will be made available to all members when the study is complete.

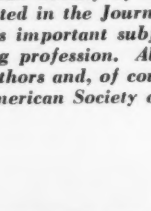
The above are but four examples of what is being done on a national level to help your Society grow in national significance.

Henry B. Duffus, President
American Society of Safety Engineers

Registration of Safety Engineers

A Panel Discussion

***EDITOR'S NOTE:** This panel discussion on the pros and cons of state registration for safety engineers has been developed by the authors from a program in which they participated at a meeting of the San Francisco Chapter, American Society of Safety Engineers. The discussion is presented in the Journal as a stimulant to further thought on this important subject by members of the safety engineering profession. All views expressed here are those of the authors and, of course, are not necessarily endorsed by the American Society of Safety Engineers.*



by William S. Tickle

THIS question of registration bothers me for a number of reasons. My basic objection is that safety engineering is too dynamic a profession to be registerable. Like an effective accident prevention program, it is constantly changing.

Many years ago, when the profession was in its infancy, the safety man needed high proficiency in basic engineering. For instance, most machinery had no guards. They had to be designed. Today, although machine guards are vital to accident prevention, the emphasis has changed from designing guards to persuading employes to use them. Or, to be more specific, the safety engineer most often must show foremen the necessity of guards and then teach *them* the art of persuasion. In the history of our profession this might be called the psychological or educational phase.

The next phase will be the "human engineering" of machines (and guards) to fit the limitations of their human operators. The skills necessary for this work do not lend themselves to registration.

Accident analysis likewise has undergone changes from the time when an accident resulted from either "an unsafe condition" or "an unsafe act." Now we know that a safety engineer must apply much observation, insight and psychology to find the underlying contributing causes which are so important in shaping attitudes and making preventive measures effective.

Today's employer expects much more of our profession than can be found in an engineering curriculum: the safety engineer is expected to be a writer, editor, advertising man, artist, lecturer, educator and statistician.

He must be able to set up research problems and sit up nights, if necessary, to work them out.

He must know something about medicine, law, insurance and adjusting so these worthies don't wreck the frequency and severity rate charts.

Now as to the qualifications for registrations — should the candidate be required to be proficient in all these fields . . . or only a few of them? How proficient must he be . . . just enough to get by? Of all the fields mentioned, most of us find it impracticable — indeed, almost impossible — to develop specialized knowledge and skills in many more fields than those which apply to the particular branches of safety engineering with which we personally are professionally concerned.

Will the overall requirements — for knowledge and skill in all the fields embraced by the safety engineering profession — be set low enough to allow all of us, with our varying specialties, to become registered? If so, it would seem that the results might be as follows:

1. Registration will level the profession so that top men are reduced to a minimum standard.
2. Registration will dull incentive for study and self-improvement, again leveling the profession to mediocrity.
3. Registration will give false security to employers. There is no guarantee of effectiveness.
4. Registration will tend to reduce the value of our Society, will tend to change its objectives to that of a union hiring hall.

Instead of letting some state agency tag us with a meaningless registration certificate, let us raise our own standards. Let's institute a professional degree based on service, education and proven ability within the profession.

by Thomas Soule

IS THERE a need for registration of safety engineers? Yes, especially for professional consultants. While there may be only a few consulting safety engineers today, the need for them is growing. At present a consulting safety engineer's practice is largely in education, inspection and organization activities. But with the technological advances now being made in industry, more

and more technical help is needed from the consulting safety engineer.

This service on the part of the safety consultant calls for a man who is well informed in electronic, chemical, radiation and complex mechanical hazards. Consulting safety engineers will be called upon to give expert advice on safety problems where a lack of technical knowledge, limited experience or immaturity on their part could be disastrous.

Today, consultants whose decisions may affect the health, economics and political well being of the average citizen are required to be registered. For example, this advisory category includes members of the medical profession, lawyers, civil and architectural engineers and land surveyors. Registration also is required for insurance and real estate agents.

We depend upon these advisers to guide us in our every day activity. We must be confident that we can trust these professional men to guide us wisely. Therefore, society has decreed that these and similar professions must meet certain established minimum standards of proficiency. Think of the chaos that society would be plunged into if anyone with just a modicum of experience or training assumed the title of an expert and, through ignorance, involved the unsuspecting client in serious legal, medical, economic or mechanical trouble.

The qualifications of the consulting safety engineer are equally important. He must possess experience, education and maturity standards that make him worthy of the trust his clients must place in him. Safety engineers often are called upon to appear as expert witnesses in court. Under the present loose definition of safety engineer, such witnesses must spend as much time qualifying themselves as experts as they do in testifying. Registration would automatically qualify a safety engineer as an expert in his line.

It is desirable to register all safety engineers who are called upon to advise on safe or unsafe conditions and who give constructive suggestions for correcting unsafe conditions or procedures. In the last 20 years accident prevention has increased in importance until the time now has come for the safety engineer to take his place beside members of the founder engineering groups. Registration of consulting safety engineers is a necessary step in raising the standards of the profession and maintaining the high level of competency we desire.

Not all civil, electrical, mechanical engineers, land surveyors and architects are registered. In a consulting firm of one of these professions it usually is required that the responsible engineer be registered. He is the man who must sign his name to the plans or specifications in their final form. The same practice could work well for safety engineers: those in a responsible consulting capacity would have to be registered and these registered safety engineers would be responsible for the acts and recommendations of their assistants.

Insurance companies are being called upon more and more to give technical safety advice. They must be conversant with such fields of safety as radiation control, noise reduction, hazardous chemical processes, control of harmful concentrations of dust, fumes and gasses, etc. This work should be handled by a responsible safety engineer. As a minimum requirement, it would be advisable to have the supervising safety engineer, in charge of a group of insurance engineers, registered. (In the California insurance engineering field, two groups of engineers whose activities affect the safety of the workmen and the general public are now required by law to be registered — the insurance elevator inspectors and the boiler inspectors.)

I do not wish to imply that only those safety engineers in the categories I have listed should be registered. I firmly believe that the privilege of registration should be extended to all in the safety engineering profession who can qualify. The more safety engineers who secure registration certificates, the sooner the safety engineering profession will be upgraded and will take its place second to no other in the engineering ranks.

by Edgar N. Goldstine

(Author's Note: The following article is written to present arguments against registration of safety engineers. However, it is immaterial to the writer whether we do or do not have registration, provided it is properly set up.)

IN CONSIDERING the registration of safety engineers, various questions arise concerning the need for it, the methods of doing it and whether the objectives sought will be achieved. Presumably the purpose is to develop standards of knowledge and practice and professional qualifications that can be readily recognized through such registration.

If the purpose is to regulate the practice of safety engineering generally, it would appear presumptuous. Excellent supervisors interested in accident prevention can and frequently do accomplish far more than most competent trained safety engineers in maintaining safe working conditions, having correct working methods used, obtaining adequate supervision and having men placed in accordance with their abilities and limitations.

State Industrial Accident Commissions and insurance companies have their own standards for employment and training, and these are or may be revised to fit changing circumstances. As accidents occur and new processes and materials develop, revisions can be made without delay, if desired.

If the purpose is to regulate accident prevention consultants, the number engaged is too small to warrant setting up legal controls. In the comparable field of medicine, the medical profession has set up its own special boards which give examinations in such fields as surgery, pediatrics, internal medicine, etc. This might correspond to fire prevention, industrial hygiene, traffic safety, industrial safety, public safety, etc. Even in industry, this could be broken down to such areas as chemical plants, construction, mining, etc. Prospective employer clients should be in a position to determine the experience and qualifications of a safety consultant without having to resort to a state registration certificate.

The work of accident prevention needs the considera-

tion and support of everyone who might be affected by it. Any individual of ability should be able to develop his own qualifications to any extent desired, limited only by his educational and personal qualifications and the amount of time, quality of effort and breadth of experience he brings to the task. His work will be recognized in accordance with his accomplishments. The record will speak for itself — far more dramatically and powerfully than any piece of paper that constitutes a registration certificate.

by A. C. Blackman

WHETHER there is a need for registration of persons engaged in accident prevention activities is, in my opinion, dependent entirely upon the need for protecting the public — in this case, the employer and his employes.

The only thing that registration accomplishes is to insure that the individual has a specific amount of education and has accumulated a definitely measurable amount of experience in his field.

Registration usually is accomplished by setting minimum standards of education and experience and permitting those who meet the standards to be registered on this basis at the time the law takes effect. This frequently is called a "grandfather" clause. After the expiration of a certain time — usually a year — any other persons who wish to be registered, in addition to meeting the minimum standards, must take a written examination to test their knowledge in the field in question.

The next portion of the discussion involves the subject of what standards should be set as the minimum. Should the individual be an engineer or is this unnecessary?

Usually, in considering such a controversial question, each individual takes a position that reflects his own personal experience. If he is not an engineer, he feels it is not necessary to be an engineer; if he has engineering training, he feels that to be successful in accident prevention it is necessary to be a trained professional engineer.

Recognizing this, it would seem advisable to *try* to be objective — to analyze the talents that are necessary and *then* determine what education and experience would be most effective in developing these talents. I'm sure that each reader has some positive ideas on the subject but I ask that he forget those ideas for a few minutes and look at the question disinterestedly, as an impartial observer.

Accidental injuries occur because man lives in and uses this physical environment he has created. This environment includes machinery, tools, structures, processes, vehicles and similar objects or methods of performing tasks. All these parts of our environment are created by persons who have technical competency in their particular areas of interest. Examples of such development are the punch press, the lathe, radiation producing equipment, etc. These things all create hazards which ultimately result in injuries.

This then raises the question as to the causes of injuries.

Some will say that "human failures cause 90 per cent of our occupational injuries; mechanical failures only 10 per cent." This would seem to justify the position that the most useful talents are those directed toward educating and training people.

On the other hand, if injury causes are classified not only under mechanical causes but also under unsafe physical environments, then I'm sure, on the basis of studies the Division of Industrial Safety of the State of California has made, it would be found that there was an *unsafe condition* in this physical environment *in some 50 per cent or more* of the injuries that have occurred.

Poor illumination, crowded layouts, uneven working surfaces, unsafe processes and methods as well as machines are all contributing causes of injuries, even in stores, restaurants, warehouses or other non-manufacturing establishments.

Considering all of this, it would seem that the person who chooses to specialize in the field of injury prevention should be concerned with, and be well versed in, both the technical aspects of our environment and the problems of human behavior. He also needs a high degree of analytical ability to properly diagnose data and factual information. Thus, safety engineering calls for a composite of many talents.

It seems to me that the basic training of vital importance is in the *physical sciences* such as engineering, which also teach the person to be analytical, thereby helping develop two important talents. This must be supplemented by additional training in human behavior, including teaching non-technical people how to live safely in a world of man-made hazards. Standards used to establish a registration system should recognize the need for all of this knowledge. I believe that such standards, over a period of years, would encourage a high degree of competence and greatly increase effectiveness of accident control programs.

But how can a person secure such well rounded training? There are very few educational institutions which have such curriculums. Being practical, it would seem easier to take the individual who has sound technical training and teach him the less exact science of human behavior, rather than to reverse the process. Perhaps the day is not too far away when this kind of education will be available on an organized basis to those who wish it.

In any event, if my reasoning is sound, it would seem logical that, should such standards be incorporated into a registration system, the employer who hires a safety engineer could be reasonably certain that this individual had talents developed to a prescribed minimum level and had acquired knowledge which would prepare him to perform his job.

Lastly — not the least in importance but not under consideration here — are the personal characteristics of the individual. Such things as personality, appearance, ability to express himself and to work with others, are certainly important. But these qualities are equally important in almost all walks of life. These characteristics could not be evaluated in any registration system nor are they presently considered, to my knowledge, in any existing system.

I hope this presentation will provoke some thought and discussion on this question.

The Safety Engineer and the Industrial Commission

by J. B. Johnson

Laws in practically all our states require employers to provide safe and healthy places of employment. While the wording may vary from state to state, the contents are essentially the same. The laws also usually provide authority for certain agencies to enter and inspect places of employment and order the correction of hazardous or unhealthy conditions. In most instances the agency making the actual inspections is under the broad general control of an Industrial Commission.

When factory safety inspection agencies were established in the early days of the safety movement, little guarding had been done in industry. For the first few years the activities of state factory inspectors, together with inspectors from the insurance companies, had an important effect in reducing injuries connected with machinery operations and other exposures.

As soon as a reasonably good standard of safe guarding had been achieved and safety engineers were being accorded a place of prominence in industry in general, the value of state inspection in accident control began to be questioned. Today some sincere members of the safety fraternity hold that state inspection is having little or no effect in preventing injuries to workers, that states maintaining extensive inspection programs do not experience substantially lower injury rates than states having little or no inspection activity.

Because such views have been publicly expressed with some frequency, the author in 1955 set out to determine, within the limitations of a questionnaire study, (1) what might be considered the cause of this apparent lack of effectiveness in state inspection, (2) what might be done to effect improvement and (3) what steps might be taken to establish an area of closer relationship between the safety engineer and the industrial commission.

In planning this study, at the outset it was recognized that in many states factory inspectors, however competent they may be, are too few in number to carry out completely the responsibilities with which they as a group are charged.

The objectives of the study called for two basic categories of information: one dealing with the qualifications of the factory inspectors (the commission representatives with whom the safety engineer has most frequent contact) and the second dealing with the degree of cooperation generally prevailing between the commission and the professional safety engineer.

A six part questionnaire was sent to the industrial commissions, or corresponding agencies, of the 48 states. The return was unusually high. Of the 48 commissions queried, 42 (87½ per cent) replied. Following are the questions asked and the information obtained:

Question 1: Are the factory inspectors of your state under civil service?

Of the 38 states which answered this question, 16 indicated that factory inspectors are under some form of civil service. In some cases, appointments are made subject to an examination. One state has competitive written examinations, one is under state personnel regulations and two are under a merit system (not defined).

But in 13 states, factory inspectors are strictly appointees. And seven states have no inspectors or factory inspection setup. In two states some inspection, principally of buildings, is done by the industrial commissioner himself.

Question 2: What training do you give your inspectors to qualify them for factory inspection work?

Next to the actual securing of inspectors, their training probably is of greatest importance. Of the 25 states which answered this question, 19 provide some type of training; six have no training whatever.

The training course developed by the U.S. Department of Labor is used by ten of the states reporting on Question 2. However, differences exist in the presentation. In some states it is supplemented by concentrated study of the codes of the states. In others the course is abbreviated in varying degree.

A second training method, "in service training," is provided in nine states. This is defined, generally, as having a new appointee travel with a more experienced inspector. In some cases such training has been effective; in other cases, of course, the trainee has learned merely to repeat his partner's errors.

J. B. Johnson is secretary and managing director of the American Society of Safety Engineers, a position he has held since 1952. He joined the Society in 1945 and became a member of the staff in 1948 after holding safety engineering positions with the National Safety Council and steel and aircraft manufacturing industries.

Question 3: Are you acquainted with the American Society of Safety Engineers?

Society members should make special note of the fact that commissions of four states answered this question in the negative. While it seems to the author that, in these instances, some slight reflection might be cast on commissioners who have not fully acquainted themselves with the country's only professional association of safety engineers, certainly the Society and its chapters are challenged to improve their public relations activities.

Question 4: Do you call upon safety engineers in your state for assistance in (a) drafting of new safety codes and regulations, (b) revision of existing safety codes and regulations?

Of the commissions reporting, 19 said they called upon the safety engineers in their states for assistance in drafting new safety codes and regulations and in revising existing codes.

The commissions' use of the professional safety engineer in this activity is documented by the annual reports of the chapters of the American Society of Safety Engineers, which each year note many instances of chapters and individual members being called upon for assistance by municipal bodies, state agencies and committees of the legislature.

As a number of state agencies have pointed out, the safety engineer is in a unique position to make a valuable contribution in such work. In addition to his technical qualifications, he is free from the pressure of special interest groups and his recommendations in most cases are found acceptable by all interested parties.

Question 5: Do you call upon safety engineers for assistance in (a) setting up inspection procedures, (b) organizing statewide or region conferences, (c) any other activities?

The wide variety of answers to this question indicated that in some states commissions and safety engineers work hand in hand; in others, there seems to be a situation of each standing alone.

In the matter of assistance by safety engineers in setting up inspection procedures, fewer agencies replied in the affirmative than to any other question. Nine said they did request and receive such help and 24 said they did not.

Perhaps this question was misunderstood. Certainly there was no thought of suggesting that safety engineers should have control over such activity, but the author most certainly believes they can be of help to inspectors. Safety engineers constantly find it necessary to learn new processes in all types of industry. Some of these processes may be quite complex; they may present baffling problems and hazards to safequard. When he has solved such problems, the safety engineer is glad to share his knowledge and his experience with others. Therefore he can be of great value to inspectors if his knowledge is utilized by them. With a mutual respect and confidence between the two parties, inspection programs can be made more effective.

Commissioners gave reports of excellent cooperation from safety engineers in the setting up of conferences. In this area the work of Society chapters and members has been so extensive that the Society usually is listed on the conference program as one of the cosponsoring agencies of the conference.

Question 6: In what way do you believe safety engineers can be of help to the state factory inspection systems?

Commissioners made many suggestions on how safety engineers can be of help to state factory inspection systems. Many pointed out instances where members of the American Society of Safety Engineers already are rendering valuable cooperation.

Reference was made above to a joint responsibility of safety engineers and commissioners and here the authors wishes to enter an area of even broader responsibility, for it is his belief that, if we are to attain the ultimate objective of the profession—that is, the reduction of accidents to an irreducible minimum in all occupations — it must be accomplished largely through the united efforts of safety engineers, state commissions, factory inspectors and management.

The safety engineer's part may lie in the extension of training programs for small plant owners or managers such as currently is being done in some Society chapters. Here the safety engineer of the larger plant is host to the small plant administrator for at least five days. The small plant man observes techniques used in the administration of the large plant's safety program which he can use in the small plant. Also he learns that the safety engineer is someone to whom he can go for counsel, encouragement and technical information. This program worked so well in one Society chapter that for two years there was a waiting list of small plant operators who wanted to take part.

The commissioner's part in the united effort may lie in bringing about a better standardization of codes, seeking always to be practical and to attain the best rather than to compromise on a minimum to get by. Inadequate as staff may be or limited as funds usually are, he must demand nothing but the highest type performance.

His factory inspectors, who are in a sense his public relations men, must be chosen carefully and trained thoroughly. The inspector must be a professional man of high integrity, capable of using good practical judgement, who commands respect and inspires confidence.

Management's part may lie in active cooperation with the inspectors and the program. This is of course a key role for, in the final analysis, in any plant it is on management that the responsibility rests for safe operations. In the past management's attitude toward factory inspection has varied, often in relation to the abilities of the inspectors. But to achieve the ultimate goal, the willing cooperation of management is necessary in every industry, in every plant, regardless of any present inadequacies in his state's inspection program.

The author realizes many may regard his proposal as idealistic. But he also believes that it will be only when safety engineers raise their sights, when they divest themselves of all politics and act as professional men, that they can ever hope to fully attain the highly moral and highly practical objectives of the safety movement.

Human Factors in Industrial Safety

by Ross A. McFarland, Ph. D.

I. INTRODUCTION

TODAY the loss of life and the incapacity resulting from all accidents are greater than those resulting from any known disease entity. In the United States each year almost 100,000 persons are killed by accidents, another 400,000 suffer some permanent disability and about 10 million are totally disabled for temporary periods of one day or longer.[1]

Of special importance is the fact that accidents are currently the leading cause of death in the younger age groups, ranking first for persons between one and 34, and second for those between 35 and 44 years.[25] This is illustrated in Figure 1. This relationship between accidents and disease implies an enormous cost to the productive resources of the country if one thinks in terms of the amount of 'lifetime" lost prematurely.[13]

In the armed services accidental trauma is now of special importance. During World War II the U.S. Army reported more deaths due to accidents than to disease, for the first time in history. Every fifth death was related to nonbattle trauma while only every eighteenth was related to disease. For the period 1942-1945, there were 60,054 deaths which were due to nonbattle casualties or a death rate of 3.06 per 1,000 each year. For the same period there were 15,125 deaths due to disease or a death rate of 0.62 per 1,000 each year. In 1950, 870 deaths were due to nonbattle injury compared with 458 deaths caused by all diseases. Vehicular accidents alone caused 45 per cent of all Army deaths due to nonbattle causes in 1952.

In the Navy and Marine Corps accidents rank first as the leading cause of mandays lost with a figure approximately three times as great as the next most common cause, the familiar upper respiratory infection. Noneffectiveness because of motor vehicles alone in 1953 (i.e., 366,000 sick days) represents the equivalent of the loss of a full combat battalion of Marines or the Navy personnel required to operate three large destroyers. And 88 per cent of those killed or injured were on leave or liberty; more than half were injured over the weekend.

A similar problem exists in the Air Force, where accidents also outweigh disease as a cause of death and noneffectiveness. Again motor vehicle accidents are the main factor, accounting for 338,025 mandays lost in 1952. Each year about 2100 service men are killed in off duty automobile accidents.[2,21]

Accidental trauma in both the civilian and military population thus may be said to have attained epidemic porportions. Although some progress in accident prevention has resulted from various research programs, it is obvious that additional intensive efforts are necessary if further gains are to be made.

II. CONTROL OF INDUSTRIAL ACCIDENTS

THE accidents described above occur chiefly on the highway, at home and in industrial operations. There are approximately 65 million people who are gainfully employed in some occupation in the United States today. In 1955, 14,200 persons were killed in accidents which occurred while at work, 75,000 suffered permanent physical impairment of some kind and 1,800,000 persons were injured so as to be unable to work for at least a day after the accident. These accidents were responsible for the loss of 235 million mandays—45 million by the workers injured, and a total of 190 million through disruption of the work of others.[1]

Great improvements have been made in industrial safety, particularly in the first third of the present century. In the past twenty years, however, the rate of improvement has been slower. It is likely that further gains may

EDITOR'S NOTE: "Human Factors in Industrial Safety" is based on material presented by the author at a Society-sponsored industrial general interest session of the 1956 National Safety Congress.

Ross A. McFarland, Ph.D., is associate professor of industrial hygiene, Harvard School of Public Health, a position he has held since 1948. Graduated from the University of Michigan, he studied at Trinity College, Cambridge, and received his doctorate at Harvard. After teaching at Columbia, in 1937 he joined the Harvard faculty and for the next ten years devoted full time to research at the Fatigue Laboratory and Division of Research, Harvard Business School. He has authorized six books and monographs and more than 100 papers on psychology and physiology, effects of high altitude and aviation medicine, human engineering, vision, industrial health and highway safety.

result from the application of newer principles from the behavorial and medical sciences, in addition to continued emphasis on safety engineering approaches.

Development Stages of Industrial Safety

The various phases of the industrial safety movement have tended to reflect what seemed to be the major deficiencies at the time. In one of the earliest stages, the emphasis was on mechanical guarding. Subsequently, the educational approach was introduced in which visual aids, demonstrations, speakers, committees and contests relating to accident prevention were used to create and maintain motivation. Further advances were made by stressing the application of basic safety engineering principles to the design of machinery, plant layout and working methods. Gradually, more emphasis was placed on the functions of supervisory personnel in safe operating practices. More recently the role of personal errors has been given attention in emphasizing the selection and proper placement of workers, based on job analyses and measurements of the functional capacities of workers.

It is now generally recognized that accidents result from a combination of causes and rarely from just one. Attempts at control or prevention must, therefore, involve consideration of the worker or operator of equipment, his tools, materials and equipment and the environment—i.e., the general work setting with all its variables. The fact that human factors appear to be of primary importance in most accidents has led some to be pessimistic of the possibility of further reducing accident rates. The view developed here is that, if attempts are made first to set forth the basic physiological and psychological characteristics of workers and these are then related to the equipment the worker uses under various specific environmental conditions, information will be obtained which will be useful in developing sound preventive programs.[13]

Management's Role in Accident Prevention

It has been demonstrated by the National Safety Council that various industries differ widely in their safety records and that some are characterized consistently by relatively high severity and frequency rates.[1] There also is a tendency for larger companies to have more favorable accident rates than the smaller ones, as is indicated in Figure 2. Many small plants, however, have excellent records. In these the owner or manager is likely to be in close contact with operations but in plants of medium size the personal contact may be lost. A safety engineer and in-plant medical facilities usually are found only in the large companies.

The size of the company, however, is of less importance than the degree of control exerted by management to prevent accidents. Management can best indicate its interest by giving staff rank to the safety director (see Figure 3) and by requiring foremen and supervisors to assume immediate responsibility for safety in their departments or shops. It is significant that industries with the best safety records require reports of each accident to be submitted routinely to the director of safety and even to management itself. In addition, the safety department is charged with the primary responsibility of intergrating the services of other departments, such as the medical and personnel departments, in the interest of loss prevention.

The personnel department can assist by improving the methods of selection, placement and training. The medical department can contribute by matching the physical capacities of workers with their jobs and by providing good in-plant medical service.[14]

Accident Analysis in Selected Industries

One of the greatest difficulties in the study of accidents is to obtain an accurate description of what occurred and under what conditions. However, accident records often may be analyzed in ways which bring to light important areas for improvement. A study made in the field of air transportation can be used to illustrate the principles involved.

An analysis of accident injury rates by class of personnel in the civil airlines has indicated that consistently, year after year, both frequency and severity rates have been excessive among the workers in line maintenance and base repair shops. On the other hand, general office, traffic, station and operating personnel have presented no particular problem in respect to either the frequency or severity rate. Table I presents a breakdown of acci-

dent rates among airline ground personnel for the five year period 1950-1954. The same trends have continued since.[14]

TABLE I

Accident Frequency Rates in Aviation Ground Employes

YEAR	NUMBER OF COMPANIES	GROUP I GENERAL OFFICE AND TRAFFIC PERSONNEL	GROUP II OPERATING STATION AND PERSONNEL	GROUP III MAINTENANCE LINE AND BASE REPAIR WORKERS
1950	11	2.8	11.6	33.5
1951	10	2.8	16.0	29.3
1952	14	1.7	16.3	26.1
1953	16	1.6	16.3	17.1
1954	18	1.1	20.1	21.0

One of the most important contributing factors to the poor record in the line maintenance and base repair shops is the wide diversity of occupational hazards that are present within the limited working areas of hangers and ramps. In these large overhaul bases men from 50 or 60 different vocational groups are required to work at high speed, often close together in small quarters. Some of the workers are exposed to bad weather and working surfaces covered with ice and snow. Another factor is the nonrepetitive nature of many of the duties and airline experience parallels that in other industries where nonrepetitive workers also tend to have high injury rates. In the Air Force as well as in civilian aviation, the high injury rate for industrial accidents constitutes a major problem. [14]

When the medical and first aid records of a number of the large companies were studied, one of the most striking features was the consistency with which particular types of injuries were repeated year after year. This is illustrated in Table II.

TABLE II

Number of First Aid Treatments among 1,500 Employes in a Large Maintenance Unit during a Two Year Period

Type of Injury	FIRST YEAR January -June	FIRST YEAR July-December	SECOND YEAR January -June	SECOND YEAR July-December
Total Injuries	1,873	1,751	1,865	2,170
SELECTED INJURIES:				
Laceration or Abrasion:				
Head	82	79	104	118
Hand or finger	806	735	766	857
Eye Injuries:				
Foreign bodies, solid	210	215	273	310
Puncture:				
Hand or finger	256	161	168	178
Sprains and Strains	48	32	62	68

It also was of interest to note changes which could be related to specific preventive practices, e.g., requiring the use of safety goggles. Such data have considerable significance for the proper training and supervision of employes as well as for the design of protective devices.

As an additional precautionary measure in the control of accidents, an illustration can be given from one of our own studies on the application of statistical quality control methods to first aid injuries. In Figure 4 the normal or expected rates based on past experience are indicated by the dashed horizontal lines. Periods in which the number of first aid injuries per 1,000 manhours goes beyond these calculated limits indicate the need for prompt investigation and appropriate action.[14]

III. ACCIDENT CONTROL THROUGH ATTENTION TO PERSONAL CHARACTERISTICS OF WORKERS

SEVERAL studies in industry have shown that when workers are selected so that their physical capacities, their skills and their aptitudes are suited to the requirements of their jobs, accident rates tend to be lower. Adequate training also has been found to be related to safety on the job and accidents are noted more frequently in situations marked by high turnover of personnel and only brief training programs for new workers.[10,14]

Personal Adjustments of Accident Repeaters

One aspect of the worker that has received a great amount of attention in recent years concerns the accident repeater and the concept of accident proneness. This originated in part from the reports of industrial physicians who noticed that a small proportion of workers in their plants seemed to be responsible for a large proportion of the accidents. One medical department, for example, reported that 80 per cent of the visits to the clinic were made by 30 per cent of the plant population. The observation that a small number of workers or drivers were responsible for most of the accidents led to the assumption that these workers were accident prone.

Statistical Studies: Some doubts have been thrown on this assumption by the statisticians. If one applies the Poisson curve to the distribution of accidents among the workers in any large industrial group, a small proportion of the group would be expected to have most of the accidents, purely as a result of chance (see Table III). [23]

TABLE III

Chance Distribution of 300 Accidents in a Group of 500 Persons

ACCIDENT FREQUENCY, PER PERSON	THEORETICAL NUMBER OF CASES
0	275
1	165
2	49
3	10
4	1

When there is an excess of workers with repeated accidents over the number to be expected by chance, the problem becomes whether these workers are accident prone and how to locate the most susceptible workers to eliminate or retrain them. Studies in this vein so far have been largely negative. For example, the actual distribution of accidents during an eight year period in a large group of aircraft pilots shows a slight excess, over

chance, of pilots with no accidents and of pilots with multiple accidents. This difference is so slight as to indicate a very negligible effect, if any, of accident proneness. In fact the slight difference may be due to nonpersonal factors, such as differences in types of mission or in types of planes flown by the individual pilots.[26]

Another approach in particular industrial groups has been to correlate the accidents sustained in one period with those sustained in a later period, to see if the same people had high accident frequencies in both. The controlled studies of this sort also have turned out to be generally negative—i.e., the same people did not have the accidents in both periods. It seems probable that an individual may have temporary predisposing conditions of a physiological or psychological nature or be exposed to variables in his environment which may lead to his becoming involved in an accident. It is therefore necessary to analyze the total accident situation to locate all the contributing causes.

Without waiting for statistical proof of accident proneness, an obvious place to start is with those individuals in any industrial group who have a history of repeated accidents and who therefore may be most susceptible. The clinical approach is one direct way of determining whether these individuals are adapted to their jobs.

Clinical Studies of Accident Repeaters: A psychiatric view of accident proneness was based on a comparison of fracture patients with patients who had not been injured. The fracture patients showed signs of repressed guilt and resentment and their accidents were traced to these unconscious feelings. Thus accidents were held to be motivated and an elaborate set of psychiatric concepts has been developed to explain the repeated accidents of certain people.[7] In considering these studies, it is important to realize that emotional states are undoubtedly of significance in many accidents. But it would be an unimaginative psychologist or psychiatrist who, *after* an accident has occurred, could not find some indication of the conflicts and repressed feelings consistent with this theory.[14]

It seems obvious that objective methods need to be developed for "predicting" or identifying in advance those persons likely to have repeated accidents, if the control of accidents is to be achieved through attention to this characteristic of the worker. In one provocative study, individuals having repeated accidents were matched with others who were accident free and compared in respect to their social adjustments. Other studies have utilized this method with groups of industrial workers and drivers and with groups of airmen in the Royal Canadian Air Force.

For example, groups of accident repeater drivers were matched with accident free groups and compared in terms of their adult court records, public health and venereal disease rates, credit bureau and social service agency contacts. The basic concept in this work was that the people involved in repeated accidents are those who have evidenced maladjustments in meeting other personal and social demands in life. In this particular

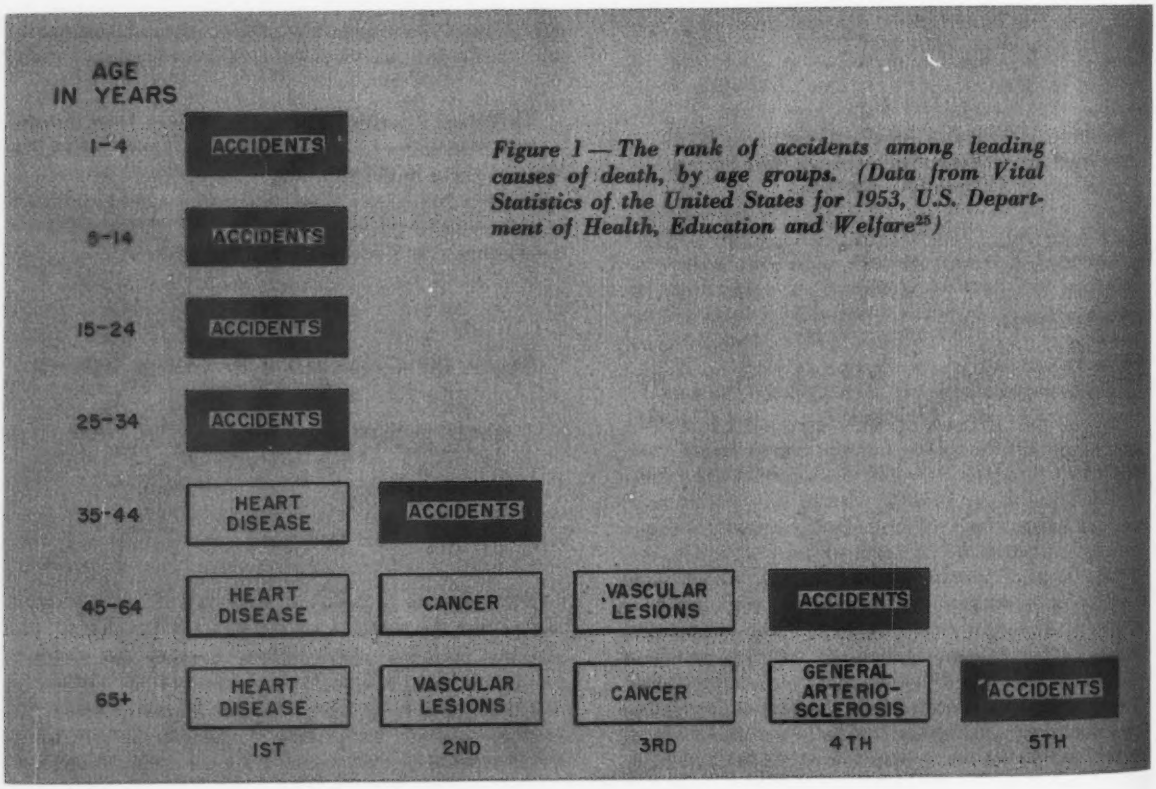


Figure 1 — The rank of accidents among leading causes of death, by age groups. (Data from Vital Statistics of the United States for 1953, U.S. Department of Health, Education and Welfare[25])

study, 66 per cent of the accident repeaters were known to one or more of these agencies, against only nine per cent of those who were accident free (Figure 5).[24]

At the Harvard School of Public Health we have repeated this approach by carefully matching accident free and accident repeater truck drivers in all the essential aspects of their work and driving experience. Very rigid criteria were set up using a large number of cases obtained from the Interstate Commerce Commission.

The procedure was found to distinguish clearly between accident free and accident repeater drivers. The relative value of selected items in discriminating the good and poor drivers is shown in Table IV. The Chi square values for the discriminating items were then used as weights for the items in a test. When this test was tried on an unselected sample of drivers, it was possible to identify 85 per cent of the accident repeaters.[17]

TABLE IV

Relative Value of Selected Items To Discriminate between Accident Free and Accident Repeater Drivers

ITEM	CHI²
Court record of automotive offenses	7.48
Minor violation in motor vehicle records	6.76
Court record of offenses against persons	6.43
Unfavorable business inspection report	3.84
Court record of offenses against self	2.55
Court record of offenses against property	2.01

It may be concluded from these studies that "a man drives as he lives." In general, those adults having repeated accidents may be characterized as having a disrespect for organized authority, showing poor social adjustment and giving evidence of permanent or transitory emotional instability. Just as delinquency may be a manifestation of the above mentioned traits, so also may repeated accidents reflect the type of adjustment or mode of life.

Implications of Age

The age of workers also has a bearing on industrial safety. It has been commonly held that the older workers are poorer safety risks than the younger ones. However, studies in several kinds of industries have now indicated that accidents are of highest frequency among the younger workers, i.e., under 30.[14,17,21] One industrial physician has termed accidents to be "an affliction of youth," since in a large series of industrial accidents he found that 50 per cent of the injuries occurred to workers under 25 years of age and the rate for the 20-24 year group was more than twice that for the 40-44 year group.[22]

Experiments carried out in England on the changes in skill with increasing age have brought out important implications for the safety of older workers. In these studies it was found that if older persons were allowed to work at their own pace they were accurate and efficient; if forced to work under time pressures, they were apt to become muddled and make errors. It also was indicated that the transfer of older workers to new types of work required training procedures in which the reduced capacity of the older person to learn novel material had been taken into account.[27]

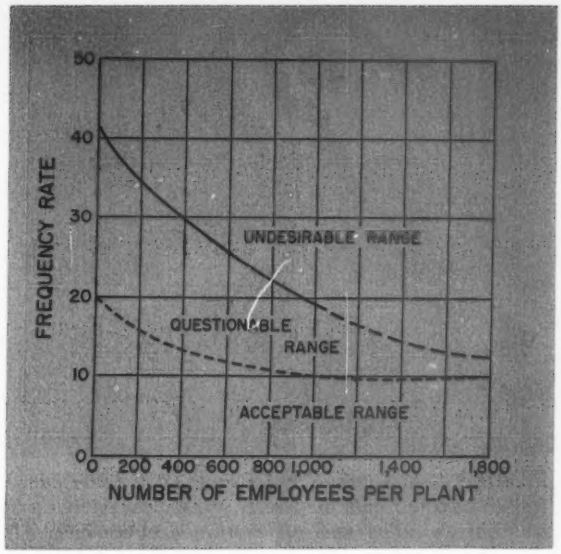


Figure 2 — The relation of plant size to frequency of industrial accidents. The figure indicates the tendency towards lower accident frequency rates in larger companies having better control measures. (Data from Liberty Mutual Insurance Company, cf. McFarland[14])

Role of Fatigue

It also must be kept in mind that the efficiency of the worker may frequently be temporarily impaired, as by fatigue or illness, from the use of alcohol or medications or by concurrent emotional stress. Errors and accidents are more likely at these times. The role of such factors is not always readily apparent. In highway transportation accidents, for example, the highest frequency is not found towards the end of a day's run; more than half occur during the first three or four hours of driving. Such factors as the time since the last major rest, nature of activities prior to driving and concurrent emotional problems may be of greater importance than the actual number of hours at the wheel. [17,19]

A better understanding of the role of fatigue in industrial accidents is gained when attention is directed to the operational changes which take place when workers are required to perform a skilled task over long periods. Studies have shown that the early signs of deterioration in skill are as follows:

1. A tendency to require a stronger stimulus before action takes place.
2. A reduction in the ability to anticipate what may take place.
3. Inaccurate timing of responses.
4. A tendency to miss cues in the periphery of the field to which the worker is responding.
5. A loss of insight into the extent of one's own deterioration.

Such behavior naturally forms the basis for errors or accidents.[4,13]

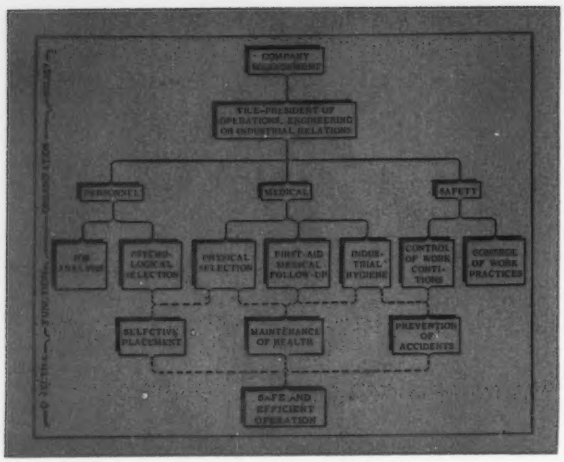


Figure 3 — The organization and basic functions of the personnel, medical and safety departments in relation to safety and efficiency in operations. The figure emphasizes the close integration that must be maintained if policies are to be effective. (From McFarland[14])

IV. SAFETY IN RELATION TO HUMAN FACTORS IN ENGINEERING DESIGN

One important way of improving industrial safety involves a closer integration of the engineering and biological sciences in the development of equipment. It is possible to show that many accidents in the military services, on the highway and at work have occurred because equipment was not designed in terms of the human limitations and capabilities of the operators.[12,16]

One illustration of this point of view may be taken from the field of aviation. There have been numerous instances where the controls for operating the flaps and landing gear have been confused because they were located too close together or reversed in position in different models. In one 22 month period during World War II, inattentive manipulation or mistaken identity or these controls caused 547 accidents in one of the armed services.

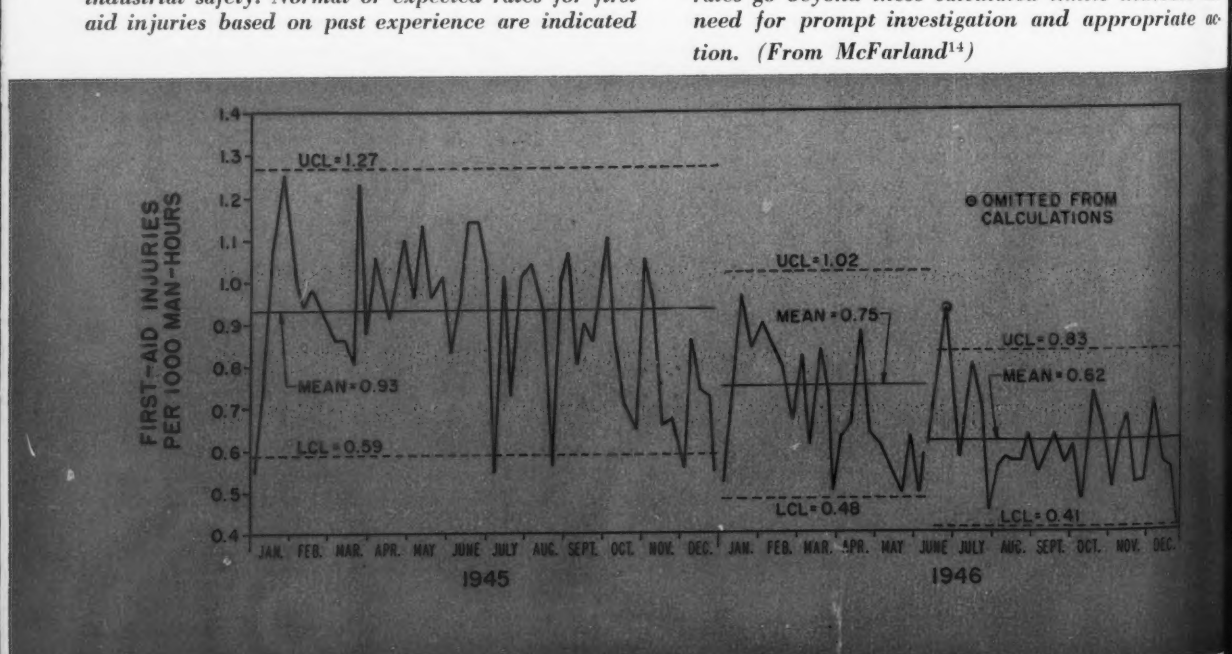
Another example is to be found in a serious highway accident which resulted when the driver of a modern automobile, traveling at night at high speed, inadvertently shut off the headlights while believing he was pushing the cigar lighter. The two knobs were identical in size and shape and located close together on the dashboard.[21]

It is becoming increasingly apparent that machines do not operate alone and that the effectiveness of any man-machine system depends on the integration of the operator with his equipment. In this view, the design of mechanical equipment must be intimately related to the anatomical, physiological and psychological characteristics of the operator. Dials and instruments intended to convey information to the worker should be considered as extensions of his nervous and preceptive systems. Levers, pedals and controls are to be viewed as extensions of arms and hands, legs and feet. Considerations of variations in body size also are important. Care also should be taken to avoid interference with established habit patterns. If the viewpoint of human engineering, or biotechnology, is carried out in practice, fewer errors and accidents in the operation of equipment should result.[6,8,9,28]

Advance Analysis of Equipment

Ideally an advance analysis should be made at the planning stage of all types of equipment to detect errors in design. This requires an operational analysis of the job, including a survey of the responses to be performed, the layout of the working area, the location of controls

Figure 4 — The use of statistical control charts for industrial safety. Normal or expected rates for first aid injuries based on past experience are indicated by the dashed horizontal lines. Periods in which the rates go beyond these calculated limits indicate the need for prompt investigation and appropriate action. (From McFarland[14])



and instruments and the way the operator carries out his functions. [17] The process is outlined schematically in Table V.

TABLE V

Areas for Consideration in the Advance Analysis of Equipment

I. Operational Job Analysis:	1. Requirements of the job. 2. Fixed limits of the working area. 3. Information derived from displays. 4. Effective integration with controls.
II. Blueprint Phase:	1. Prediction of efficiency. 2. Implications of human limitations. 3. Anticipation of errors.
III. Mockup Stage:	1. Direct observation of required performance. 2. Provisions for variations in body size. 3. Determination of skill requirements. 4. Analysis of errors and near accidents. 5. Operations at a biomechanical advantage.E 6. Human limitations and physiological stress.

A functional concept of accidents is a basic consideration in advance analysis. That is, the errors and accidents which may occur during operation should be anticipated. The limitations of human capacities also must be considered, otherwise the operator may be forced beyond his abilities and reserves. Finally, a wide margin of safety should be provided since adverse factors such as fatigue or physiological stress may increase the operator's limitations.

Equipment Design in Relation to Body Size

One of the most important considerations in the proper design of equipment relates to the *range of human body size*. If vehicular equipment, for example, is designed for the person of average size, a considerable proportion of drivers who are either larger or smaller than the average may be discommoded in various ways. As a part of a study at Harvard on how well commercial vehicles are suited to their operators, an anthropological team measured approximately 360 truck drivers, in various sections of the country. The distributions for three of the dimensions which are of special importance in driving are shown in Figure 6.[15]

In several of the truck models studied, only five per cent of the driver population could be expected to reach and operate the hand brake comfortably. In others, there was insufficient clearance between the brake pedal and steering wheel for a tall driver to operate the foot brake except by angling the knee out to the side; this clearance was adequate for only 60 per cent of the drivers. In one of these models, the tallest 15 per cent of the drivers would be unable to raise the foot to the brake pedal when the shift lever was in either of the two left positions, since the lever prevented the tall driver from moving his knee to the side of the wheel.

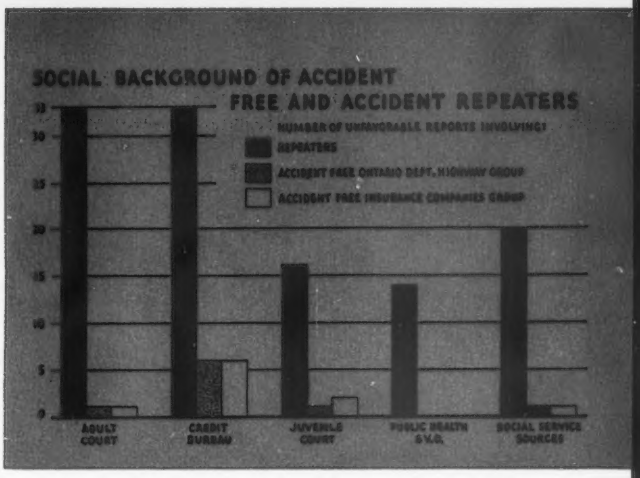


Figure 5 — Social adjustments of accident repeater drivers, compared to accident free drivers. Figure shows the number of persons having record of contact with selected agencies in a group of 96 accident-repeaters and two groups of 100 accident free drivers. Drivers were matched for experience and were driving in the same geographic area. (Data from Tillmann and Hobbs[24])

Numerous instances also were observed where the location of controls or switches made operation difficult. For example, in some trucks the dimmer button was located directly underneath the clutch and brake pedals and very close to the steering post, making the successive operation of these controls difficult.[17,20]

While anthropologic data on static human dimensions are of great importance for the design of equipment, consideration also must include the dynamics and biomechanics of men at work. One needs to study how a man is seated at his job, how far he has to reach, what force he can bring to bear on his controls—and to design the work space and controls in the light of the operator's capabilities and limitations. The use of mockups of equipment is an essential step which reveals many design errors not apparent at the blueprint stage.[19]

Design of Instruments and Controls

In the evalution of vehicles mentioned above, it was found that *the design of many dials and gages* could be expected to hinder rapid and accurate reading of the information they convey. The following factors are important in regard to the ease of seeing:

1. Size and spacing of critical detail, especially in instrument markings and figures.
2. Contrast between object and immediate background.
3. Amount of illumination, including the use of color.
4. Contrast between the objects to be seen and their surroundings.

Design criteria for dials, gages and pointers, based

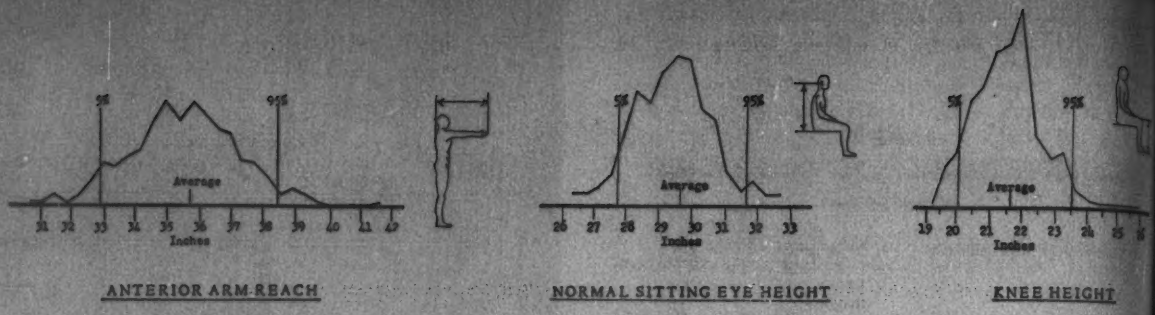


Figure 6—Distributions of the body measurements of truck and bus drivers. The distribution of anterior arm reach, normal sitting eye height and knee height for more than 300 truck and bus drivers are shown, The average values are indicated and the range, including the middle 90 per cent of drivers. (From McFarland et al[15])

on human visual capacities, have been determined experimentally [3,6,8] (see Figure 7). Safety and efficiency also may be improved if controls are designed and located so that they may be operated accurately and at biomechanical advantage. The mistaken identity or inadvertent operation of controls may be prevented through shape or color coding (see Figure 8).

In general, it may be said that any control unnecessarily hard to reach and operate, any instrument difficult to read, any seat inducing poor posture or discomfort or any unnecessary obstruction to vision may contribute directly to an accident because of the effect on the performance of the driver. Man is a poor monitor of equipment and where safety considerations are involved, anything which might be done to monitor the driver by means of warning devices is highly desirable.

In addition, it should be kept in mind that both men and machines are likely to become unstable or break down under overloads. Finally, the cumulative effects of undue burdens imposed by poor design features are sure to induce fatigue, resulting in the overall deterioration of operating efficiency and perhaps leading to an accident.

V. INFLUENCE OF ENVIRONMENTAL VARIABLES ON SAFETY

ENVIRONMENTAL influences which may effect the efficiency and safety of industrial workers are shown schematically in Figure 9. For each of these variables, limits to define areas of comfort, discomfort and physiological harm have been worked out. These variables are fairly well understood if considered by themselves singly.[19] For instance, if noise levels exceed certain limits, speech communication will be interfered with to the compromise of safety; with still greater intensities of noise, impairment in hearing may result (see Figure 10).

There is difficulty in using single numerical values as limits, however, since a change in one variable often influences other factors. For example, the acuity of hearing is a function not only of the intensity and frequency of sound but also of the age of the person. With increasing age there is a progressive loss of hearing sensitivity, particularly for the higher frequencies. Thus the evaluation of a hearing loss in relation to exposure to industrial noise also requires a consideration of the hearing changes which are normal for a given age.[14]

Interaction: Worker, Equipment, Environment

A final illustration taken from the field of highway safety is one which clearly brings out the need for considering the person, the equipment and the environment in terms of their interrelationships. The National Safety Council has observed that accident rates on the highway are some three times higher at night than during the daytime.[1] It is reasonable to believe that the poorer rates at night are at least partly related to the lower illumination.

If a driver is in a vehicle equipped with a tinted windshield, the light reaching the eye from the highway is reduced since the colored glass absorbs about 28 per cent of the light passing through it, as compared with 12 per cent for clear safety glass.[17] While this may be of

Figure 7 — Principles in the design of dials for rapid reading. The two on the left require the operator to interpolate between numbers on a scale and to interpret a numerical value, whereas the necessary information can be obtained directly from the dial on the right at a glance. (From Baker and Grether[3])

negligible significance in many instances, it may be of considerable importance for the safety of the older driver, whose ability to perceive dim objects under low illumination already is reduced.

The correlation between age and complete dark adaptation is one of the highest thus far reported between age and a biological function and it is well established that older persons require more intense illumination to see at night than do younger persons. This change usually is noticeable by the age of 45 or 50 and becomes quite marked at later ages.[14,18]

The same complexity characterizes almost every other environmental variable. For example, the generally accepted standard of safety for carbon monoxide is 0.01 per cent in circulating air. This figure applies quite satisfactorily for a person sitting quitely at sea level but it should be reduced if the amount of exercise, rate of ventilation or duration of exposure increases. Moreover, if the person is a chronic cigaret smoker, his blood already may be five to ten per cent saturated with carbon monoxide. Thus, a series of variables has to be considered and their effect on human performance and safety can best be understood through developing nomograms where the influence of the several variable together can be evaluated.[20]

Figure 8 — The shape coding of handles and knobs to prevent mistaken identity and inadvertent operation. The shapes in the top row can be distinguished from each other by touch alone with a high degree of accuracy. Those in the bottom row provide accurate visual discrimination when there is good color or brightness contrast with the background. (From Jenkins, cf. McFarland et al,[15] *and from Sleight, cf. Baker and Grether)*

VI. SUMMARY AND CONCLUSIONS

A SIGNIFICANT reduction in industrial accidents may be achieved through an adequate understanding of: (*a*) the employe, (b) the worker in relation to his equipment and (c) the environmental setting. Some improvement can result from the proper selection, training and supervision of the worker. The analysis of near accidents and emergencies porvides valuable clues to the prevention of real accidents. It also is necessary to understand the role of such factors as personal adjustments, age and the influence of temporary lapses in efficiency.

It is of great importance that the worker be integrated effectively with his equipment. The design of machines and equipment in terms of the human capabilities and limitations of the operator is one area where close collaboration between the engineering and biological sciences can result in fewer errors and accidents in industrial operations.

The working environment also may be subjected to a high degree of control, which should be based on understanding the complex relationships between human and environmental variables influencing the comfort, efficiency and safety of workers.

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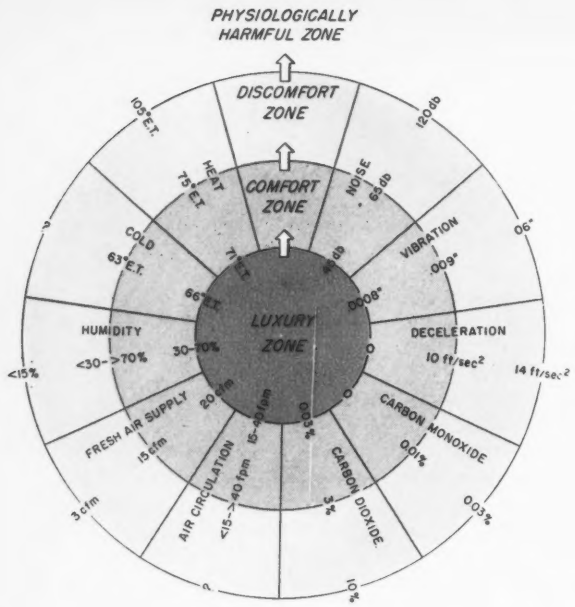

Figure 9 — The physical variables of the environment influencing the comfort, health and safety of workers. The values shown must be considered approximations since each variable is interdependent with one or more additional factors.)From McFarland[19])

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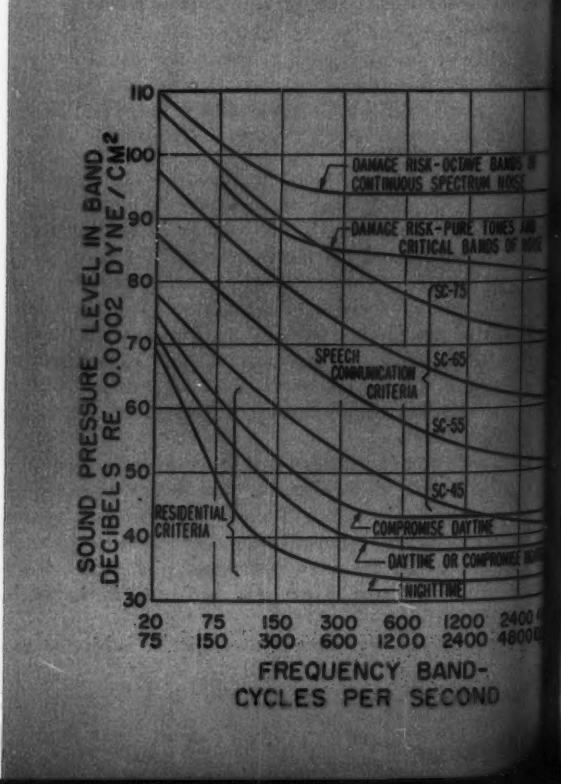


Figure 10 — Tentative criteria for noise control design. The figure shows the noise and sound levels which involve the risk of damage to hearing and levels having an influence on the efficiency of speech communication (SC). At SC 55 decibels conversation is possible at several feet with the normal voice. Communication is difficult at SC 65 and can be carried on at SC 75 only by shouting. (From Bolt et al[5])

Canons of Ethics for Engineers

Foreword

Honesty, justice and courtesy form a moral philosophy which, associated with mutual interest among men, constitutes the foundation of ethics. The engineer should recognize such a standard, not in passive observance, but as a set of dynamic principles guiding his conduct and way of life. It is his duty to practice his profession according to these Canons of Ethics.

As the keystone of professional conduct is integrity, the engineer will discharge his duties with fidelity to the public, his employers and clients, and with fairness and impartiality to all. It is his duty to interest himself in public welfare and to be ready to apply his special knowledge for the benefit of mankind. He should uphold the honor and dignity of his profession and also avoid association with any enterprise of questionable character. In his dealings with fellow engineers he should be fair and tolerant.

Professional Life

Sec. 1. The engineer will cooperate in extending the effectiveness of the engineering profession by interchanging information and experience with other engineers and students and by contributing to the work of engineering societies, schools and the scientific and engineering press.

Sec. 2. He will not advertise his work or merit in a self-laudatory manner and he will avoid all conduct or practice likely to discredit or do injury to the dignity and honor of his profession.

Relations with the Public

Sec. 3. The engineer will endeavor to extend public knowledge of engineering and will discourage the spreading of untrue, unfair and exaggerated statements regarding engineering.

Sec. 4. He will have due regard for the safety of life and health of the public and employes who may be affected by the work for which he is responsible.

Sec. 5. He will express an opinion only when it is founded on adequate knowledge and honest conviction while he is serving as a witness before a court, commission or other tribunal.

Sec. 6. He will not issue *ex parte* statements, criticisms or arguments on matters connected with public policy which are inspired or paid for by private interests unless he indicates on whose behalf he is making the statement.

Sec. 7. He will refrain from expressing publicly an opinion on an engineering subject unless he is informed as to the facts relating thereto.

Relations with Clients and Employers

Sec. 8. The engineer will act in professional matters for each client or employer as a faithful agent or trustee.

Sec. 9. He will act with fairness and justice between his client or employer and the contractor when dealing with contracts.

Sec. 10. He will make his status clear to his client or employer before undertaking an engagement if he may be called upon to decide on the use of inventions, apparatus or any other thing in which he may have a financial interest.

Sec. 11. He will guard against conditions that are dangerous or threatening to life, limb or property on work for which he is responsible or, if he is not responsible, will promptly call such conditions to the attention of those who are responsible.

Sec. 12. He will present clearly the consequences to be expected from deviations proposed if his engineering judgment is overruled by nontechnical authority in cases where he is responsible for the technical adequacy of engineering work.

Sec. 13. He will engage or advise his client or employer to engage, and he will cooperate with, other experts and specialists whenever the client's or employer's interests are best served by such service.

Sec. 14. He will disclose no information concerning the business affairs or technical processes of clients or employers without their consent.

Sec. 15. He will not accept compensation, financial or otherwise, from more than one interested party for the same service or for services pertaining to the same work without the consent of all interested parties.

Sec. 16. He will not accept commissions or allowances, directly or indirectly, from contractors or other parties dealing with his client or employer in connection with work for which he is responsible.

Sec. 17. He will not be financially interested in the bids as or of a contractor on competitive work for which he is employed as an engineer unless he has the consent of his client or employer.

Sec. 18. He will promptly disclose to his client or employer any interest in a business which may compete with or affect the business of his client or employer. He will not allow an interest in any business to affect his decision regarding engineering work for which he is employed or which he may be called upon to perform.

Relations with Engineers

Sec. 19. The engineer will endeavor to protect the engineering profession collectively and individually from misrepresentation and misunderstanding.

Sec. 20. He will take care that credit for engineering work is given to those to whom credit is properly due.

Sec. 21. He will uphold the principle of appropriate and adequate compensation for those engaged in engineering work, including those in subordinate capacities, as being in the public interest and maintaining the standards of the profession.

Sec. 22. He will endeavor to provide opportunity for the professional development and advancement of engineers in his employ.

Sec. 23. He will not directly or indirectly injure the professional reputation, prospects or practice of another engineer. However, if he considers that an engineer is guilty of unethical, illegal or unfair practice, he will present the information to the proper authority for action.

Sec. 24. He will exercise due restraint in criticizing another engineer's work in public, recognizing the fact that the engineering societies and the engineering press provide the proper forum for technical discussions and criticism.

Sec. 25. He will not try to supplant another engineer in a particular employment after becoming aware that definite steps have been taken toward the other's employment.

Sec. 26. He will not compete with another engineer on the basis of charges for work by underbidding through reducing his normal fees after having been informed of the charges named by the other.

Sec. 27. He will not use the advantage of a salaried position to compete unfairly with another engineer.

Sec. 28. He will not become associated in responsibility for work with engineers who do not conform to ethical practices.

Prepared by
Engineers' Council for Professional Development
and adopted by the Executive Committee,
American Society of Safety Engineers,
December 12, 1948

AMERICAN SOCIETY OF SAFETY ENGINEERS

Membership Information

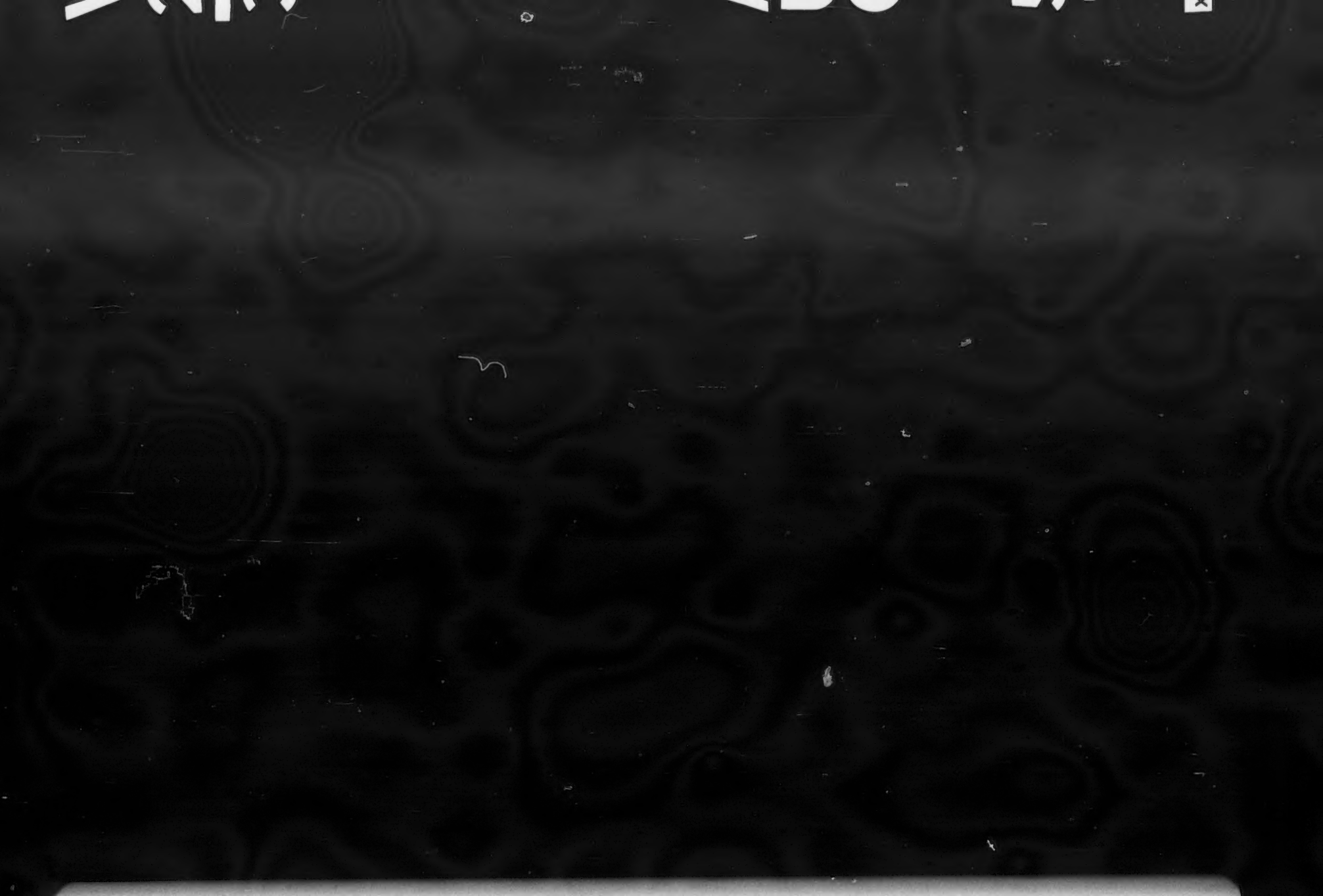
THE American Society of Safety Engineers has established the following classifications of active membership:

MEMBER —To be eligible as a Member an applicant shall be at least thirty years of age and shall be engaged in safety engineering. In addition, he shall have either an engineering or science degree in an accredited college curriculum and the equivalent of eight full years' experience in safety engineering; or he shall have had the equivalent of ten full years' experience in safety engineering.

ASSOCIATE MEMBER —To be eligible as an Associate Member an applicant shall be at least twenty-five years of age and shall be engaged in safety engineering. In addition, he shall have either an engineering or science degree in an accredited college curriculum and the equivalent of three full years' experience in safety engineering; or he shall have the equivalent of five full years' experience in safety engineering; or he shall have either an engineering or science degree in an accredited college curriculum, ten years' experience in professional engineering work and one full year's experience in safety engineering; or he shall have twenty years' experience in engineering work, of which at least ten have been at the professional level, and one full year's experience in safety engineering.

JUNIOR MEMBER —To be eligible as a Junior Member an applicant shall be at least twenty years of age and shall be engaged in safety engineering work, which if pursued the required time will tend to qualify the applicant for the grade of Associate Member. In addition, he shall have either an engineering or science degree in an accredited college curriculum or he shall have had the equivalent of one full year's experience in safety engineering.

AFFILIATE MEMBER —The Society also provides a special classification, that of Affiliate Member, for those not professionally engaged in safety engineering. To be eligible as an Affiliate Member an applicant shall be at least twenty-five years of age and shall have contributed to the advancement of safety engineering through demonstrated achievement in some related field of interest in which he has been engaged for at least three years.

for additional information write to

The American Society of Safety Engineers
425 North Michigan Avenue
Chicago 11, Illinois
(or contact your local chapter)